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Costs of drying buttermilk in Iowa creameries

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COSTS OF DRYING BUTTERMILK IN IOWA CREAMERIES

by

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INTRODUCTION

Butter manufacturing utilizes approximately 80 percent of the milk produced in Iowa. In 1951, 200,000,000 pounds of butter were produced in Iowa creameries. In the same year, 7,035,000 pounds of buttermilk powder were produced; this represented approximately 25 percent of the buttermilk produced in Iowa creameries. The buttermilk not processed into powder is sold in fluid form for animal feed, condensed and sold as semi-solid buttermilk for animal feed, or disposed of as waste.

The buttermilk that is disposed of as waste, and perhaps that which is used in fluid form for animal feed, could be utilized more effectively if it were dried by the roller process and sold for feeding purposes as powder.

In 1951, 69 plants processed buttermilk. However, many creameries did not process their buttermilk. In many instances, apparently, this was due to a lack of information concerning methods and costs of processing. The problem that confronts dairy plants is the determination of methods and processes that can be used to utilize buttermilk most effectively. Information concerning methods and costs of processing would enable creamery operators to process their product at a lower net cost and increase profits or pay a higher price for butterfat.

Roller drying is one method of processing buttermilk in plants receiving chiefly cream and, judging from the number of dryers in the state, it is perhaps the most logical method. This study was designed to determine the conditions under which it is feasible to dry buttermilk by the roller process. It is not designed to compare the feasibility of various methods of drying. It is only concerned with the conditions under which it is feasible to dry buttermilk by the roller process.

Economic theory leads us to believe that the factors that exert influence relative to the decision to roller-dry buttermilk are: (1) scale of output, (2) capital outlay or marginal expenditure for equipment, whichever is pertinent, (3) work organization of the plant, and (4) the expected market prices for dry and fluid buttermilk. Former studies, referred to later in the review of literature, lead us to believe that the scale of output or volume of production is the most important of the unknown variables. The determination of the relationship existing between cost of processing buttermilk powder and the volume of butter production will enable us to determine whether, in any particular plant, roller drying buttermilk and selling it as animal feed is likely to be a more economical method of utilization of buttermilk than disposing of it as animal feed in fluid form or disposing of it as waste. The objectives of this study are to examine: (1) the effect of volume of butter production on the costs of processing buttermilk and (2) the effect of alternative markets for fluid buttermilk on the net return realized from buttermilk powder.

In 1951 Frazer, Neilsen and Nord investigated the costs of manufacturing butter in Iowa creameries. This investigation was specifically concerned with the effect of volume of butter production on the cost of butter manufacturing. The present analysis of the cost of manufacturing buttermilk powder is a supplement to the butter manufacturing cost study. Since buttermilk is a by-product of butter manufacturing, an analysis of the processing cost of buttermilk can be used in conjunction with an analysis of butter manufacturing cost as an aid in creamery management.

REVIEW OF THE LITERATURE

There are few published studies which deal with the cost of buttermilk drying. Oderkirk, in his investigation of dry buttermilk in Iowa,[1] based his cost figures on managers' estimates for 21 plants. These plants reported costs for drying buttermilk ranging from 1.67 to 5.2 cents per pound. He also showed two examples of departmentalized accounting for the drying operation. The purpose of these examples was to show the wide variation existing in accounting procedures from plant to plant. Oderkirk stated that a significant correlation (0.4904) existed between reported cost and volume of buttermilk powder produced. Oderkirk's study is mainly descriptive, but it does help in showing that a relationship does exist between cost and volume. He also recognizes the need for further research in this field.

The investigation conducted by Oderkirk is the only research that has been done on buttermilk drying in Iowa. However, a considerable amount of cost research has been done in dairy plants in connection with other production activities. These studies are valuable in that the methodology developed in some is directly applicable to

[1] A. D. Oderkirk. Dry Buttermilk in Iowa. (Mimeo. rept.) Iowa Agricultural Experiment Station. 1946.

the present study. One such study is Bressler, Frick and Henry's investigation of the costs of specialized pasteurizing and bottling plants in Connecticut.[1] Scott Walker is at the present time conducting cost research on multi-product western creameries. These results, however, have not as yet been published.

In Bressler, Frick and Henry's investigation, the methods developed for determining fuel and electricity costs in milk plants provide a basic formula from which adaptations were made to determine these costs in buttermilk drying operations in the present study. Bressler, Frick and Henry's method used the specific heat of milk, the caloric requirements for raising the milk temperature to the desired level, and the heat content of the fuels used to determine the fuel cost in pasteurizing. The electricity cost was determined by using the theoretical watt input per motor horsepower and the length of time in operation. The input requirements in both fuel and electricity were properly adjusted for efficiency factors whenever such adjustment was necessary.

Frazer, Neilson and Nord's[2] study of butter manufacturing costs was useful in that the method devised for standard-

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[1]R. G. Bressler, G. F. Frick and W. F. Henry. "Efficiencies of Milk Marketing in Connecticut" 11. Economies of Scale in Specialized Pasteurizing and Bottling Plants. Bul. 259. Storrs Agricultural Experiment Station. 1948.

[2]J. R. Frazer, V. H. Neilson and J. D. Nord. The Cost of Manufacturing Butter. Bul. 389. Iowa Agricultural Experiment Station. 1952.

izing building costs is applicable to the plants under observation in the present study. This method combined depreciation and maintenance costs and calculated them as four percent of the investment.

METHOD AND PROCEDURE

Methods of Measuring the Relationship Between Volume and Cost

The relationship that exists between volume of butter production and cost of production of buttermilk powder may be measured in two ways. One method is the statistical approach. When a problem is analyzed statistically a relatively large number of observations are needed. This is necessary because the larger the number of degrees of freedom the more reliable are the results. In a statistical analysis the input data are taken as observed and a production function is computed by the use of regression techniques. The result of a statistical analysis are tested for significance by use of tests of significance and by establishing confidence limits.

Another method is the engineering approach. In the use of this method, the input values are determined by use of engineering data.[1] These engineering data are used in constructing hypothetical, but not necessarily average, plants. They are above average, but within the range of what can be

[1]Engineering data are values assigned to input factors. These values are determined by use of theoretical values with adjustments made for efficiency and other factors which may influence the value of an input.

achieved in the industry. These hypothetical plants are constructed for various volume ranges, and at each volume the hypothetical plant is considered to have an optimum combination of inputs. This method has an advantage in that differences in techniques are considered and accounted for in the construction of the hypothetical plants.

In the analyses of the effect of volume of butter production on cost of buttermilk processing in the sample plants, a combination of the statistical and engineering method was used. A sample composed of creameries in the lower volume range was selected.

Standardized rates per unit for the inputs such as labor, machinery, buildings, packaging, fuel and electricity were used. The cost of processing was determined by using these standardized rates and the actual physical quantities of the inputs used. The total cost and the cost per unit of processing buttermilk were constructed for outputs of 550,000 pounds, 850,000 pounds, 1,250,000 pounds and 1,430,000 pounds of butter produced annually. These hypothetical plants were constructed by using the engineering method and the quantities of the physical inputs and the work organization as determined by use of engineering data. The specified volumes of butter production in the hypothetical plants were chosen because they lie within the volume range of the sample plants, and therefore the results obtained from the hypothetical plants can be more easily compared to the results obtained in the sample plants. By the use of the engineering method, a cost per unit of output was derived for plants within the relevant range.

Selecting the Observed Plants

The plants observed in the present study are creameries which produce less than two million pounds of butter annually and include the smallest creameries that have drying equipment. Plants in this volume range were selected because it is in this volume range (or lower) where the break-even points are expected to occur. The break-even point is that volume below which costs exceed returns and a manager would find it unprofitable to install a drying system.

The plants to be studied were made more homogeneous by restricting the area studied to plants meeting the following conditions:

a. They received cream only.

b. They did no condensing.

c. They produced no by-product other than buttermilk.

The imposition of these conditions reduced the information from all plants drying buttermilk because of the smaller numbers of plants observed. The selection of plants meeting the above set of conditions increased the precision of the precision of the measurements and reduced the variation between plants greatly. It is believed that this gain, plus the reduction in costs, more than compensates for the loss of information and lack of applicability of statistical tests.

The plants were selected in the following manner: A list of creameries having dryers was obtained from the Iowa Department of Agriculture, Division of Dairy and Foods. A letter with an enclosed card was sent to the 69 plants contained in this list. The following questions were asked on this card:

1. Do you receive milk____ or cream____ or both____?
2. Do you have a dryer?
3. Type of dryer, spray ________ roller________?
4. Products Dried   Approx. Volume 1951

    Dried Buttermilk

    Semi-solid Buttermilk

    Dried Skimmilk

    Other
5. At what prices are you selling dried buttermilk to farmers?

Sixty-six of the 69 plants returned the card. Eighteen of the 66 plants responding met the conditions set forth above. These eighteen plants were then sent a letter with a short schedule enclosed which asked for the following information:

1. What is the year of installation, brand name, model and size of your roller dryer?
    a. year installed
    b. brand name and model
    c. length of roller
    d. diameter of roller
2. What is the maximum dry product output per hour that you have obtained? _______lbs.
3. How many hours a day is your dryer in actual operation in the peak production month?_______hrs. per day.
4. What was your butter production in 1951?_______lbs.

This schedule was sent out on the premise that those plants not responding would be visited to obtain the informa-tion. This method greatly reduced the time and money ex-pended in obtaining the desired information. Ten of the eighteen plants returned the schedule and the remaining eight were visited.

On the basis of the information received from these eighteen plants, we determined that seven of these 18 plants produced less than two million pounds of butter annually and were using equipment that was presently available. These seven plants constituted the observation units in the present study. The techniques of production and the cost per unit of processing buttermilk powder were determined by visits to these plants.

Method of Determining Inputs in the Observed Plants

The amount of physical inputs used in the observed plants varies to some extent. This variation is due to the effects of several variables, including type of equipment, amount of steam pressure, condition of buttermilk, and differences in quantities of labor required. This variation of input factors is not necessarily related to volume. The price for the various physical inputs, therefore, was standardized to remove such variation not due to volume. The method of standardizing these inputs is explained later for each input. The prices applied to inputs are given and explained in Appendix A.

The input factors may be divided into three categories for cost determination purposes. The category into which they were placed was determined by the degree to which the investment was fixed.

To illustrate this, assume three time periods -- period one, the initial planning period prior to any investment at which time all costs are variable. In this period the input factors can be combined in any manner suitable to the planners. Period two, which we will call the secondary planning period, occurs after the initial investment has been made. Building, equipment, insurance and taxes are fixed costs. However, labor, fuel, electricity, and packaging are still variable and can be used in any combination desired. Period three, which we will call the tertiary planning period, covers a monthly or weekly operating period. In this period labor becomes fixed and the costs of labor are incurred regardless of the level of output. Fuel, electricity and packaging are still variable.

It can be seen from this illustration that the costs involved in buttermilk processing can be divided into three categories. The first category includes the costs which are incurred and fixed as soon as the drying system is installed. These costs are not a function of output and exist at all outputs or at no output. The second category is the category where the decision to operate the system for a certain period of time will cause additional costs to become fixed. In this period volume does not effect the total cost of this newly fixed input and any output above zero will incur the total cost of this input. The third category is the category of costs which are incurred in direct proportion to volume and as such vary directly with volume.

This division of inputs into three cost categories creates a category of costs which are neither fixed nor variable, but which are fixed in one time period and variable in another time period. Labor falls into this class. By making such a division we can determine the labor input more easily in the construction of the hypothetical plants. This division allows a planner to take advantage of various systems of work organization and permits the selection of a work schedule which is most economical for each plant. This selection of a system of work organization occurs in the period where decisions are made concerning the operation for a period of one year. In other words it lies between the long run period of fixed investment and the short run period of day to day operations.

The building, equipment and boiler can be included in the first category. The cost of these inputs is determined by applying a standard rate for all sample plants. These costs are broken down into depreciation cost, obsolescence cost and user cost. Depreciation and obsolescence are incurred whether a plant produces or stands idle; user cost, however, is defined as that loss of capital value that is a result of use and it is calculated as a function of use or output. Therefore, that portion of building, equipment and boiler cost that is user cost falls into the third cost category. Only depreciation and obsolescence costs are relevant for the category of costs which are incurred by factors which are a fixed investment. In this particular instance, however, user cost for the boiler, equipment and building are very small. Indeed, it may well be that the boiler, building and equipment costs may be higher at zero output than at maximum output. This could occur if the lack of lubrication and maintenance on the equipment and the corrosive action on the boiler and the lack of ventilation and maintenance on the building would shorten the useful life of these factors more than operation would. With the type of factors, building, dryer and boiler, that are used in drying this may well be the case. The dryer is a larger, heavy, slow moving machine and lack of lubrication on the bearings and exposure of the rolls to the atmosphere could easily be more detrimental to its useful life than operation would be. The life of the boiler is probably prolonged by use, for constant use aids in arresting the corrosive elements, such as sulfur found in coal, and retards rust damage to the fire tubes. The building cost is not likely to be affected by use. The cost of ventilation and repairs are likely to be more than offset by a less rapid depreciation of the building when in use.

The charge for obsolescence is also very small, for up to the present time no radical innovations in the atmospheric roller drying technique have been made. The type of equipment in use now is much the same as the equipment twenty years ago, so the charge to obsolescence for equipment would be very small. The same is true of boiler and building. For all practical purposes all the costs of building, equipment and boiler can be charged to depreciation and interest.

The second category of costs includes labor. The input of labor is zero if zero output is produced, but whenever any amount above zero is produced the entire labor input is used. This is true because the labor force is customarily hired on a yearly basis. The work organization involving the dryer operator is based on the requirements of the peak season and, regardless of variation in output, the dryer operator continues working at the hours stipulated and the input chargeable to labor is the same throughout the year. The work organization during the peak season must be considered fixed throughout the year, because buttermilk powder volume is dependent upon the volume of butter production, and if buttermilk powder production is low in the slack season and the dryer operator is not fully occupied for the length of the working day, then the other creamery workers are also not fully occupied. Because of this over-supply of labor in the creamery in the slack season the entire labor charge of the peak season has to be borne throughout the year.

The third category includes factors such as fuel, electricity and packaging. These factors vary directly with volume and as such are used in proportion to the volume produced. User cost of capital items is also in this category but, as stated previously, for this type of capital items it can be ignored.

The cost of depreciation, obsclescence and interest for building, equipment and boiler will be determined as follows:

Building costs for all sample plants are determined on the basis of replacement cost. These costs are standardized by using a building space of the same dimensions as the building space in use at the present time. The replacement cost is determined by using Boeckh's Manual of Appraisals[1] and the Boeckh Index Calculator Tables.[2] A standard depreciation (including maintenance) rate of four percent of the replacement cost and an interest rate of four percent of the average investment is applied.

Equipment costs are determined in somewhat the same manner as building cost. An inventory of all equipment in use in the sample plants is taken and a replacement cost applied to all equipment. This replacement cost is the current cost as quoted by dairy equipment manufacturers. These prices include installation charges wherever such charges are applicable.

The depreciation and rates applied to the various pieces of equipment are the rates set up by the Bureau of Internal Revenue.[3] Interest cost is calculated as four percent of the average investment. The maintenance rate applied to

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[1]E. H. Boeckh. Boeckh's Manual of Appraisals. 3rd Edition. The Rough Notes Company Inc. Indianapolis, Indiana. 1937.

[2]The Boeckh Index Calculator Tables. The Rough Notes Company Inc. Indianapolis, Indiana. 1936.

[3]U.S. Treasury Dept., Bureau of Internal Revenue. Bulletin "F," Income Tax Depreciation and Obsolescence Estimated Useful Lives and Depreciation Rates. Revised January, 1942.

equipment is four percent of the investment.[1]

An appropriate proportion of the boiler cost is charged against the drying operating. This proportion is determined by obtaining the percentage of the total fuel used in drying in 1951 (this figure is arrived at by a method explained later for determining fuel cost and charging this percentage of the depreciation charges for the boiler to the drying operation. Interest is computed in the same way as equipment cost: Four percent of the average investment, adjusted for the percentage of the boiler charge applicable to drying.

The costs of insurance, local taxes, and payroll taxes are computed at standardized rates for all sample plants. These rates are given in Appendix A.

The labor cost is determined as follows:

a. An eight hour day is considered a standard day.

b. The annual wage rate is standardized on the basis of an eight hour day and a six day week.

c. The entire time the dryer operator works in the peak season is charged to drying. If other plant duties connected with the dryer are performed also, this time is also charged to the drying operation. The percentage of the total day that the dryer operator works in the peak season is the percentage of the

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[1]See Appendix A for explanation of all rates to input factors.

total annual wage which is charged to drying. The tax and insurance costs due to labor are calculated by using a standardized rate for all plants and the percentage of the total annual wage charged to labor in each plant.

The fuel, electricity and packaging costs incurred in buttermilk drying are determined as follows:

Packaging cost:

Packaging costs vary directly with volume. The rate per unit is standardized for all plants, as described in Appendix

Fuel and electricity cost:

The fuel cost, c, for producing 100 100 pounds of dry buttermilk is determined by the following formula:

$$c = \frac{\left[\left(\frac{100}{a}\right)(100) - (100)\right](b + d)}{(.93)(.65)(e)}(f)$$

a = percent solids in fluid buttermilk
b = latent heat of vaporization at the steam pressure used
d = B.T.U.'s required to raise 100 pounds of fluid buttermilk from the original temperature to 212 degrees Fahrenheit (this assumes the specific heat of buttermilk to be one)
.93 = dryer efficiency[1]
.65 = boiler efficiency[2]
e = B.T.U.'s present in one pound of coal
f = standard price per pound of coal

[1]Determined with the help of Prof. H. M. Black, Mechanical Engineering Dept., Iowa State College.

[2]Determined with the help of Prof. H. M. Black, Mechanical Engineering Dept., Iowa State College.

Electricity:

Electricity costs were computed for each motor in the plant. The following formula is used:

$$c = \left(\frac{x}{1000}\right)(y)\left(\frac{1}{w}\right)(u)(p)$$

c = cost of electricity per motor

x = theoretical watts per hour per horsepower

y = number of horsepower

w = the efficiency[1] of the motor

u = number of hours in operation

p = standard price per K.W.H. of electricity

Hypothetical Plants

The volumes of the hypothetical plants were chosen to coincide with the volumes of observed plants and to provide an approximately equal volume interval between plants. Four hypothetical plants were constructed on the following basis:

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[1] Efficiencies for various types of motors were computed with the help of J. Nillson of the Electrical Engineering Dept., Iowa State College.

a. The selection of an adequate sized building.

b. The selection of equipment large enough to process the buttermilk during the peak season.

c. The selection of a boiler capable of handling the dryer and all other creamery operations during the peak season.

d. The determination of the labor requirements for output during the peak season.

e. The determination of fuel, electricity and packaging requirements from engineering data based on output of the selected equipment under good management.

f. The determination of insurance and taxes by the same method used in the sample plants.

The rates for all the foregoing costs will be the same standardized rates as are used in the sample plants.

Method of Analysis

The relationship existing between cost of processing buttermilk powder and volume of butter production can be analyzed in two ways. A statistical approach, or an engineering approach,[1] can be used. If the statistical approach

[1] For a further discussion of the engineering method see A. R. Ferguson. Empirical Determination of Multidimensional Marginal Cost Functions. Econometrica. Vol. 18, No. 3: pp. 217-235. July, 1950, and Hollis B. Cheney. Engineering Production. Quarterly Journal of Economics. Vol. 43: pp. 567-537. Nov., 1947.

is employed the results are based on what exists in the industry at the present time, and the effect of the different variables on cost is determined by analyzing the differences between plants. In this study, however, not enough plants were available for a statistical analysis. Another reason for not employing statistical methods in determining the effect on costs of various variables is that observed costs are not the most important for the purposes of this study. The costs that are important are those costs that can be achieved in the industry under a reasonable degree of good management. The statistical approach gives results based on what now exists, and not on what can be done, as does the engineering approach. If the engineering approach is used and hypothetical plants are constructed, the costs of the various input factors are determined by formulas such as those used for calculation of fuel and electricity requirements. Any change in the factor amounts or prices can easily be taken into account and also any change in technique can be taken into account. To illustrate this: Suppose the fuel cost was affected by increased boiler efficiency or by a change in the price, then all that is necessary to determine the new fuel cost is to make the necessary boiler efficiency adjustment and the price per unit adjustment for fuel. This can be done for any change occurring in the variables; therefore, the effect of each variable upon the cost of processing can be determined.

There are also limitations of the engineering approach. First, frequently the physical interrelationships that exist in a plant cannot be determined or are inaccurate, and if these relationships cannot be determined the necessary formulas for measuring various inputs cannot be developed. In a situation of this type the statistical approach must be used for obtaining the physical production function. Second, if this method of analysis were used for each input in a complex industry it would require a great amount of time and energy. The results obtained from such an analysis, however, are more useful in that they show precisely the effect of each input upon the total cost of processing.

PROCESSING COSTS OF BUTTERMILK POWDER, COMPUTED ON THE BASIS OF THE OBSERVED WORK ORGANIZATION IN THE OBSERVED PLANTS

Observed Plants

The annual butter production in the seven sample plants ranged from 547,000 pounds to 1,434,000 pounds. The annual butter production and the cost of manufacturing buttermilk powder for each sample plant is shown in Table 1. These data are shown graphically in Figure 1.

Table 1. Volume of butter production and adjusted processing cost of buttermilk in seven sample plants[a]

Plant	Volume of butter manufactured	Cost per pound to roller-dry buttermilk powder
A	547,000	8.13
B	852,000	5.66
C	968,000	4.69
D	1,153,000	5.01
E	1,250,000	4.77
F	1,315,000	3.82
G	1,434,000	4.15

[a]It would have been desirable to present a reasonable range of costs which may be experienced in the industry. This, however, was not possible in the present study.

The manufacturing costs shown in Table 1 and Figure 1 are not the observed costs but are costs computed by applying standardized factor prices to the observed physical inputs. This standardization procedure was adopted in order to

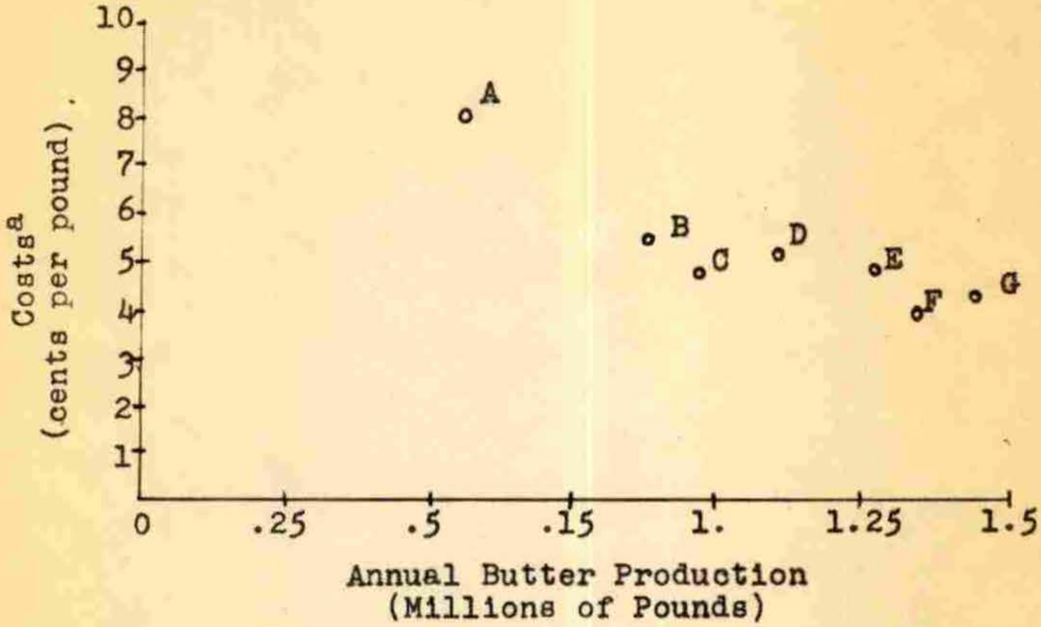

Fig. 1. Relationship between the costs of drying buttermilk by the roller process in Iowa and the volume of production of butter.

[a]Computed according to the work organization observed in the sample plants.

eliminate differences not due to volume. The rates applied are conservative in all cases. A plant could obtain fuel, electricity, insurance equipment and labor for these rates in all cases except where a peculiar local situation would cause these rates to be higher. Therefore, the production costs shown in Table 1 and in Figure 1 are conservative. In many instances a plant could process buttermilk for a lower cost. Only in a relatively few cases would the production cost be higher.

Table 1 shows a general decline in costs per pound as volume rises, except for deviation in Plants D and E. The higher costs in Plants D and E are due to specific causes. In Plant D the higher fuel cost occasioned by an over-loaded boiler is the principal cause for the higher cost. In Plant E the principal causes for higher costs are a low level of labor efficiency, a larger size equipment than is necessary, and a slightly higher fuel cost, which is caused by the low level of labor efficiency. The slightly lower cost in Plant F compared to Plant G is mainly due to better work organization in the plant and slightly smaller equipment size.

This figure shows that there is a general decrease in cost as volume increases. In each case where the cost rises with greater production, there is a specific reason for it. These deviations will be explained more fully in the sections below devoted specifically to building and equipment, labor, fuel and electricity and packaging.

Building and Equipment

The building and equipment costs in this study were based on new construction and new equipment. In some instances this made the computed building and equipment costs higher than the actual equipment and building costs in the sample plants. This was especially true in equipment. The prices actually paid for the dryers in the sample plants ranged from $2,500.00 for a used dryer to $13,500.00 for a completely new installation. The replacement cost of the $2,500.00 dryer was $10,000.00 and the equipment cost for that plant was computed on the basis of the $10,000.00 replacement cost. This method of determining cost of equipment is very conservative. Any plant is able to achieve an equipment cost as low as the computed cost; in many instances a lower equipment cost can be achieved.

The expenses included in building and equipment cost are depreciation, maintenance, and interest on investment. Depreciation and maintenance costs of buildings are combined into one charge which is calculated as 4 percent of the investment. Interest cost on buildings is calculated as 4 percent of the average investment. The equipment expense, as previously pointed out, is divided into depreciation cost, which is determined by the rates given in Bulletin "F";[1] maintenance cost, which is calculated as four percent of the investment;[2] and interest cost, which is calculated as four percent of the average investment.[3] By applying these standard rates to all sample plants, the building and equipment charges are equitable between plants.

Table 2 shows building and equipment costs for the sample plants. The data are presented as total annual costs and costs per pound of buttermilk powder manufactured.

The building costs are fixed. Accordingly the building costs per unit, in a given plant or between plants of different volumes, must decrease as volume increases. This occurs because a plant producing 1,000,000 pounds of butter annually does not require a building twice as large as a plant producing 500,000 pounds of butter. This relationship was found to be generally true in the sample plants. The building costs for the sample plants ranged from .23 cents per pound to .115 cents per pound. Plant A's building cost of .23 cents per pound was the highest, yet the working space was too small and lacked proper ventilation. Plants B and D achieved low building costs at the expense of venti-

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[1] U. S. Treasury Dept., Bureau of Internal Revenue. op. cit. p. 34.

[2] See Appendix A for rates and explanations.

[3] See Appendix A for rates and explanations.

Table 2. Total building and equipment costs and building, equipment, insurance and tax costs as costs per pound of buttermilk powder in seven sample plants

Plant	Annual butter production (pounds)	Building cost		Equipment cost		Insurance cost per pound of buttermilk powder (cents)	Local property tax costs per pound of buttermilk powder (cents)
		Annual cost (dollars)	Cost per pound of buttermilk powder (cents)	Annual cost (dollars)	Cost per pound of buttermilk powder (cents)		
A	547,000	157.00	.23	1,442.00	2.12	.39	.34
B	852,000	159.00	.17	1,553.00	1.68	.27	.27
C	968,000	292.00	.21	1,840.00	1.34	.24	.23
D	1,153,000	250.00	.16	1,549.00	.99	.17	.17
E	1,250,000	300.00	.20	1,750.00	1.18	.21	.21
F	1,315,000	225.00	.17	1,622.00	.83	.14	.15
G	1,434,000	344.00	.15	1,942.00	.88	.16	.16

lation, adequate working space, and storage space. The lack of ventilation, adequate working space, and storage space made drying buttermilk a hot, odorous and generally unpleasant job. Plants C, E and F had adequate working space, good ventilation and enough storage space. Plant G had good ventilation and ample storage space but would have benefitted from a slightly larger working space.

The equipment costs are also fixed, and the equipment cost per unit, in any given plant of between plants of different volumes, would be expected to decrease as volume increases. This occurs because a plant producing 1,000,000 pounds of butter annually does not require twice as large an investment as a plant producing 500,000 pounds of butter annually. This is generally the case in the sample plants. The equipment costs for the sample plants ranged from 2.12 cents per pound to .827 cents per pound. Plant A, the smallest plant in the sample, had the highest equipment cost. Plant E had higher equipment costs than it should have had at that volume. This is due to the excess capacity of the equipment. The equipment in use in Plant E was designed to produce from 200 to 220 pounds of powder per hour. This machine is designed for a much larger volume of production and its use in a plant of this volume (250,000 pounds of butter per year) results in a high equipment cost. Plant F had a slightly lower equipment cost than Plant G, which had a larger volume. This slightly lower equipment cost was mainly due to a smaller dryer size. The difference in dryer size represented an additional investment of $5,000 in Plant G. This larger dryer size was required to handle the volume of Plant G, but the difference in volume was not large enough to cover the additional investment of $5,000. Plant F could not have produced a much greater volume with the present equipment but Plant G could have increased output somewhat without incurring additional equipment expense. Plant F realized some slight economies by using a gravity feed to the dryer; this, however, had a very slight effect on the equipment costs.

Insurance and Taxes

The insurance rates paid by the sample plants ranged from $0.67 per $100 to $2.98 per $100. The insurance rate used in the analyses was standardized at $1.35 per $100 for building, $1.45 per $100 for equipment and $0.096 per $100 for extended coverage.[1] This standardization of insurance rates made the insurance costs a function of size of building and equipment, which is in a large measure dependent upon volume of production.

Since insurance costs are a function of equipment and

[1] See Appendix A for explanation of rates.

building size, which in turn is a function of volume, insurance costs per unit, like equipment costs per unit, should decrease as volume increases. With the exception of Plants E and G this occurred in the sample plants. The insurance costs per unit ranged from .394 cents to .158 cents per pound. Plant E had a higher insurance cost per unit than the smaller volume Plant D. This again reflects the excess equipment capacity in Plant E. Plant G's insurance cost per unit was higher than the smaller volume Plant F. This too was caused by the additional investment required in the larger Plant G. The volume difference was not great enough to permit the plant to attain the economies attained by Plant F in operating at nearly full capacity.

The local property tax rate varied from 34 mills per dollar at 60 percent valuation to 92 mills per dollar at 60 percent valuation. This variation in local property taxes shows the great difference found in tax rates throughout the state. This difference is not caused by volume of production but is caused by purely local conditions. Because of this wide variation in rates, the tax rate was standardized. The rate used was 30 mills per dollar at 100 percent valuation. This is equal to 50 mills per dollar at 60 percent valuation. Standardizing the tax rate made the tax cost per unit a function of building and equipment size, which as stated previously, is closely associated with dependent volume.

Table 2 shows the tax costs per unit of buttermilk powder processed. Since tax costs, like insurance costs, are a function of building and equipment size, tax costs per unit would be expected to decrease as volume increases. With the exception of Plants E and G, this occurred in the sample plants. The tax costs per unit in the sample plants ranged from .343 cents per pound to .156 cents per pound of buttermilk powder. Plant E had a higher tax cost per unit than the smaller volume Plant D. This, like the insurance cost per unit, is due to the excess equipment capacity in Plant E. Plant G had a higher tax cost per unit than the smaller volume Plant F. This is caused by the same additional equipment investment in Plant G that was discussed previously under equipment and insurance costs.

Labor

Labor, along with equipment and fuel, represents one of the major inputs in buttermilk drying. The monthly wage observed in the sample plants varied from $185 to $275. Only one operator, however, was paid less than $200 per month and five of the seven operators received from $255 to $275 per month. The wage rate for dryer operators was standardized at $260 per month for a 48 hour week. The use of a standardized wage rate for the dryer operator made the labor cost a function of efficiency, that is, the labor cost is a function of the skill of the operator and the manner in which labor not needed at the dryer is utilized in the plant.

Table 3 shows the labor cost per unit of buttermilk powder manufactured. The labor cost per unit ranged from 3.63 cents to 1.21 cents per pound. Labor cost per unit generally decreased as volume increased. This was expected, because once the decision to operate has been made and labor is hired, the total labor cost is incurred and as volume increases the cost per unit will decrease.

Table 3. Labor cost per pound of buttermilk powder manufactured in 7 sample plants

Plant	Annual production of butter (pounds)	Labor costs per pound of buttermilk powder (cents)
A	547,000	3.63
B	852,000	1.75
C	968,000	1.23
D	1,153,000	1.21
E	1,250,000	1.39
F	1,315,000	1.23
G	1,434,000	1.44

Plant A, which had the lowest volume of butter production, was expected to have the highest labor cost per unit. This was found to be true; the labor cost per unit, however, could have been reduced quite substantially with more efficient management. The high labor cost per unit in Plant A was due to the low labor efficiency and poor work organization in the plant. This operator dried the buttermilk and operated the gas fired boiler. The operation of the boiler consisted of watching the pressure gauge and regulating the gas feed valves. This operator had no incentive to become more efficient. He had to spend 8 hours a day in the plant, and so long as the dryer was operating he would not be required to work in other parts of the plant. This caused him to spend much more time drying buttermilk than was necessary.

Plant E also had a higher labor cost than the volume of production warranted. This again was caused by low labor efficiency. This operator also worked in the plant when he completed the day's drying. No specific duties were assigned him in the plant and the operator had no incentive to finish. As long as he was drying he would not be called upon to work in the plant. This plant also had excess equipment capacity. The excess equipment capacity coupled with the low labor efficiency was the major cause for the high cost in relation to the volume.

In Plants C and F the dryer operator had specific plant duties to perform when he finished drying buttermilk. This was an incentive for the operator, and as a result, the drying operation was completed as rapidly as possible. In Plant C the operator was assigned specific duties in the plant cleanup. In Plant F the operator was assigned several specific jobs such as making butter boxes for the next day. These specific assignments increased labor efficiency by providing an incentive for the dryer operator because, when these duties were completed, the operator had finished his day's work.

Plant D also had an incentive for the dryer operator. In this plant the operator owned and operated his own cream route. He made his daily collection and then dried the day's buttermilk. When he completed drying he was through for the day; this incentive helped to reduce labor costs.

Plant G was the only plant observed where the operator was hired full time to dry milk. This plant had the largest volume of production but the dryer operator could have operated the boiler in addition to drying. In the case of Plant F this was not done, and the boiler operator was also the mechanic for the creamery-owned collection trucks. It is difficult to determine just how the work organization in this plant could have been changed to take advantage of the small amount of labor (one hour per day) not needed at the dryer. This unused labor, however, was the major cause for the slightly higher labor cost of Plant H compared to Plant F.

Fuel and Electricity

The cost of coal observed in the sample plants ranged from \$8.60 per ton to \$13.55 per ton. This price includes freight and unloading. The higher fuel prices observed were the prices charged by local dealers; the lower prices observed were paid for coal direct from the mine. Most creameries used southern Illinois coal. In the two plants not using coal, the fuel prices were 32 cents per thousand cubic feet of natural gas, and 11.6 cents a gallon, delivered, for fuel oil. The electricity rate varied from 2.6 cents per kilowatt hour to 4.23 cents per kilowatt hour. The variation in fuel and electricity costs was not due to volume of production, but was due to local conditions. Because the variation was due to local conditions, the fuel and electricity costs were standardized; the rates used were \$9.00 per ton for fuel (including freight) and 3.2 cents per kilowatt hour for electricity. These rates and the sources of these rates are given in Appendix A.

By standardizing the rates per unit the electricity cost becomes a function of size of equipment and labor efficiency. This occurs because the electricity cost depends upon the size and length of operating time of the motors. With a standardized rate per kilowatt hour the electricity cost per unit is expected to decrease as volume increases. This is expected because the motor size and the operating time increase at a less than constant rate as volume increases.

Table 4 shows the fuel and electricity cost per unit.

The electricity cost per pound decreased as volume increased. Plant D was the exception. Its higher cost can be attributed to the increased consumption of electricity caused by using a three horsepower motor where a one and one half horsepower motor would have been sufficient. If a motor of proper size had been used in Plant D the electricity cost per unit would have been lower in Plant D than in Plant C. The larger investment occasioned by this larger motor was not great enough to materially effect the equipment costs.

Table 4. Costs of fuel and electricity per pound of buttermilk powder in seven sample plants

Plant	Annual production of butter (pounds)	Electricity cost per pound of buttermilk powder (cents)	Fuel costs per pound of buttermilk powder (cents)
A	547,000	.42	.52
B	852,000	.34	.65
C	968,000	.22	.69
D	1,153,000	.25	1.53
E	1,250,000	.19	.86
F	1,315,000	.18	.69
G	1,434,000	.17	.66

By standardizing the price per unit of fuel, the fuel cost per pound of powder becomes a function of labor efficiency and solids content of the buttermilk. The fuel cost per unit is expected to remain constant as volume increases. This constant fuel cost per unit is expected if the labor efficiency is at the same level and the solids content is the same from plant to plant. The fuel costs are shown in Table 4. They remained fairly constant for Plants B, C, F and G. The differences occurring between these four plants can be attributed to the differences in the solids content of the buttermilk. These four plants all used coal for fuel in stoker fired boilers.

Plant A achieved a low fuel cost because natural gas was used for fuel. Natural gas is a more economical fuel than coal. The cost per 1000 B.T.U.'s is .026 cents, compared to .04 cents per 1000 B.T.U.'s for coal. Natural gas, however, is not available in all areas and therefore this advantage is not available to all plants.

Plant D's high fuel cost per pound of powder resulted from using an overloaded boiler. The boiler size was too small to operate a dryer while the other creamery operations were being performed. For other reasons in addition to the overloaded boiler, the fuel cost per 1000 B.T.U.'s was higher than in any other plant. The cost per 1000 B.T.U.'s for fuel oil is .07 cents compared to .026 cents for natural gas and .04 cents for coal. Plants A and D were the only plants in the sample using a fuel other than coal. This prevents a comparison of the fuel costs between plants using natural gas and oil as fuel.

In the remaining plants, Plant E was the only one that deviated greatly from the remainder of the group. This higher fuel cost per unit in Plant E can be attributed to the low labor efficiency mentioned previously.

Under efficient management, with a reasonable level of labor efficiency, the fuel costs per unit should be fairly constant for all plants using the same type of fuel. This can be seen in Plants B, C, F and G. These plants had varying degrees of labor efficiency and varying levels of solids in buttermilk. Even with these differences, however, the fuel cost per unit varied only .048 cents per pound from the lowest to the highest fuel cost per unit in these plants.

Packaging

Buttermilk for animal feed is usually packaged in 100 pound burlap bags with a waxed paper liner. This method of packaging was used in all plants in the sample with the exception of Plant C. Plant C packaged the powder in fifty pound paper bags. Since this was the only plant observed not packaging powder in burlap bags the cost per unit of packaging was standardized as the cost of a burlap bag and a waxed liner. The cost of burlap bags and waxed liners ranged from 39.2 cents to 56.1 cents for a bag and liner. The rate used in the cost computations of the sample plant was 52.5 cents for a bag and liner. Buttermilk is sold in

100 pound bags and the cost per unit of packaging is constant from plant to plant if the cost per bag and liner is standardized as it was in this case.

In the analysis of the processing cost per pound of buttermilk powder in the sample plants, standardized rates per unit have been applied to the physical inputs observed in the sample plants. The equipment and building costs were based upon replacement costs of new equipment and new buildings. The fuel, electricity, insurance, tax and packaging rates applied are considered reasonable for creamery operations in Iowa. The wage rate is the approximate wage rate paid most dryer operators observed. In the sample plants the volume of production, fuel and electricity inputs and work organization were accepted as observed and a cost per pound for processing was computed for each sample plant. The rates applied to inputs are conservative and in some cases the sample plant may be processing buttermilk for less than the computed cost. This, however, is the result of taking advantage of a local situation. This would occur in cases where used equipment is available, where the present building space is adequate, or where a nearby fuel supply, such as a coal mine, reduces fuel and freight costs. By taking advantage of any such local conditions a creamery could, in many instances, process buttermilk at a lower cost per pound than the costs computed in this study.

PROCESSING COSTS OF BUTTERMILK POWDER, COMPUTED ON THE BASIS OF A DESIGNED WORK ORGANIZATION FOR EACH OF FOUR PLANTS

In the preceding section the costs of processing buttermilk were computed after standardizing the rates per unit of labor, building, equipment, fuel, electricity, and packaging. The building size, equipment size, butter production, fuel input, electricity input and work organization were not standardized. These factors were accepted as observed in the sample plants. All these factors, with the possible exception of butter production, could be classified as being under the control of management. Because these factors are under the control of management, the conditions found in the sample plants may not represent the requirements of a typical buttermilk drying operation, but may be due to unique conditions present in each sample plant. In order to eliminate such a possibility hypothetical plants have been constructed. In these plants all the inputs have been standardized. This was done to eliminate, as much as possible, the variation in costs that was not due to volume.

In the construction of hypothetical plants, the butter production was predetermined, and the solids content of the buttermilk was standardized. The equipment size and building size were determined for the requirements of the peak production month. The equipment and building cost was based on replacement cost, and the method of computation used was the same as in the sample plants. The work organization of the sample plants was designed to provide the most efficient use of labor considered practicable.

The prices applied to these calculated inputs were the same as those prices applied to the inputs of the sample plants. Standardizing the prices applied to inputs, and basing the equipment and building cost on replacement costs of new equipment and building space, resulted in a conservative cost of production. A creamery contemplating installation of a completely new drying system could process buttermilk powder for the cost computed in these hypothetical plants. In many instances a creamery could produce buttermilk powder for less than the computed cost. This would be the case where used equipment is available or where the building space presently available would be adequate to house the drying system. Also, advantages in purchasing other inputs, low tax rates, high solids content in the raw material and other peculiarities might reduce costs in individual plants below those presented here, but it is likely that deviations in one factor will be offset by deviations in the other direction in another input. Therefore, outside of advantages in labor supply, dryer prices and building space, it is not anticipated that individual plants will be able to commence drying buttermilk at significantly lower costs.

In constructing these four hypothetical plants the following assumptions were made:

a. That 1.67 pounds of buttermilk are produced for each pound of butter produced.[1]

b. That 11 percent of the annual butter production is produced in the peak month.[2]

c. That 26 days are available for drying in the peak production month.

Even though there may be variation in production of butter within a week, the buttermilk can be stored on days of large production and dried on succeeding days when butter production declines.

d. That the solids content of buttermilk is 8.7 percent.

These assumptions were needed to standardize the annual buttermilk powder production and the buttermilk powder production of the peak month.

The equipment sizes in the hypothetical plants were determined from the powder production and the hours of labor available per day for drying in the peak production month.

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[1] C. N. Eckles, W. R. Combs, and H. Macy. Milk and Milk Products. 3rd edition, pp. 14-321. McGraw Hill Book Company. New York. 1943.

[2] J. R. Frazer, V. H. Neilsen, and J. D. Nord. op. cit. p. 815.

A dryer large enough to handle the peak production in the specified time was installed. The combination of equipment and labor that resulted in the lowest per unit processing cost was chosen.

The building size for the hypothetical plants was determined by the size of the equipment and annual production. In the hypothetical plants separate storage space for three weeks' powder production was provided. This storage space was provided because a creamery with adequate storage space is not nearly so dependent upon local feed manufacturers and patrons for buttermilk powder sales. If they have storage space a creamery can accumulate a large enough quantity to make it profitable to ship powder to markets outside Iowa. A storage space larger than that needed for three weeks production was not provided because buttermilk powder, unless refrigerated, does not keep for more than three weeks without serious quality deterioration. The annual building cost in the hypothetical plants was computed in the same way as in the sample plants. A diagram of the equipment arrangement for the 550,000 pound plant is shown in Appendix B. This arrangement is the same for all plants. The only difference in building space between plants is that difference caused by equipment size.

The work organization of the hypothetical plants was based on the creamery labor requirements. In two cases a portion of the dryer-operator's labor was used in the creamery. This was done whenever such division of available labor resulted in a lower processing cost and the labor requirements of the creamery made it possible. In no case was a dryer-operator required to work more than eight hours per day. The rates for labor, workman's compensation insurance, and payroll taxes are the same as used in the sample plants.

Insurance costs and local property tax costs were computed in the same manner in the hypothetical plants as in the sample plants.

Fuel and electricity costs were computed by use of the same formulas used in the sample plants. Coal was used for fuel in all plants at a standardized cost of .71 cents per pound, which compared favorably with the fuel cost per unit of the sample plants using the same type of fuel. The solids content of the buttermilk, which ranged from 8.26 to 9.48 percent in the sample plants, was standardized at 8.7 percent. Standardizing the solids content of the buttermilk and choosing the dryer size and rate of production caused the fuel cost per unit from plant to plant to be constant.

The electricity cost per unit for the hypothetical plants was computed in the same way as in the sample plants. The slightly higher electricity cost in Plant IV compared to Plant III was caused by the larger motor required for the dryer in Plant IV. The jump from a 7.5 horsepower motor to a 10 horsepower motor caused this rise. If the motor sizes had increased in increments of one horsepower, this increase would not have occurred.

The packaging cost per unit used in the hypothetical plants was the same as the cost per unit used in the sample plants.

The annual butter production and cost per pound of processing buttermilk powder, computed as explained above, is shown in Table 5. These data are shown graphically in Figure 2.

Table 5. Volume of butter production and manufacturing costs of buttermilk powder in four hypothetical plants

Plant	Volume of butter manufactured annually (pounds)	Cost per pound to manufacture buttermilk powder (cents)
I	550,000	7.43
II	850,000	5.19
III	1,250,000	4.55
IV	1,430,000	4.03

Plant I

Plant I, with an annual butter production of 550,000 pounds, had a cost of 7.43 cents per pound of buttermilk powder manufactured. The cost per pound of buttermilk powder for each input is shown in Table 6.

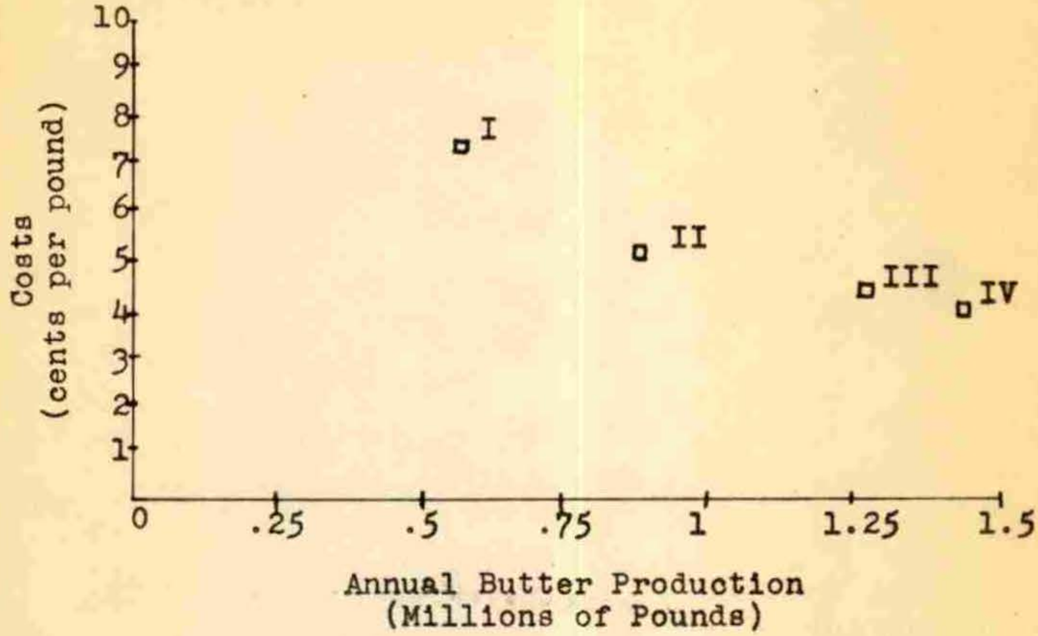

Fig. 2. Relationship between the cost of drying buttermilk by the roller process and the volume of production of butter in four plants with a designed work organization.

The major cost items in a plant of this size are labor and equipment. This high labor and equipment cost is caused by the low volume of production.

The work schedule of the dryer operator in Plant I is shown in Figure 3. In this plant the dryer operator is used

Table 6. Costs of manufacturing buttermilk powder in four hypothetical plants. (Cents per pound)

	Plant I	Plant II	Plant III	Plant IV
Annual butter production (pounds)	550,000	850,000	1,250,000	1,430,000
Fuel	.78	.71	.71	.71
Electricity	.32	.21	.21	.21
Packaging	.53	.53	.53	.53
Labor	3.01	1.82	1.64	1.43
Equipment	1.89	1.34	.88	.83
Building	.23	.21	.15	.13
Insurance	.30	.24	.16	.15
Taxes	.29	.23	.16	.15
Total cost per pound	7.43	5.19	4.55	4.03

part time in the receiving room and in the boiler room. Having the dryer operator work in the receiving room substantially reduces the labor cost per unit, and labor is available in the creamery when it is needed most. A larger dryer size is required when the dryer operator does not

Annual butter production 550,000 pounds

9:00 A.M.	
	Sharpen knives
10:00 A.M.	Set up conveyor, splash guards
	Work in receiving room
11:00 A.M.	
	Heat up dryer, agitate milk
12:00 M.	
1:00 P.M.	Dry buttermilk, sack and store powder, keep stoker filled, eat lunch at the machine
2:00 P.M.	
3:00 P.M.	
4:00 P.M.	Clean up dryer and floor and shut down equipment
5:00 P.M.	Haul out ashes, clean boiler room and prepare boiler for next day

Fig. 3. Work Schedule - Plant I.

devote his full time to drying. This increases the equipment cost by .03 cents per pound. The labor cost, however, is substantially reduced, and a net gain of 1.41 cents per pound is realized. This assignment of a specific task each day also increases efficiency at the dryer. The operator knows that when the drying is completed his day's work is finished. This provides an incentive for the operator to operate the dryer at full capacity. The dryer operates most efficiently at full capacity and a high dryer efficiency aids in reducing the costs of processing.

Plant II

Plant II, with an annual butter production of 850,000 pounds, had a cost of 5.19 cents per pound of buttermilk powder manufactured. The processing cost per pound of buttermilk powder is shown for each input in Table 6. The costs of Plant II were 2.24 cents per pound lower than the costs of Plant I. This lower total cost per pound was largely due to the decreased cost per pound for equipment and labor. In Plant I the equipment and labor cost per pound totaled 4.90 cents. In Plant II these costs totaled 3.16 cents per pound. This is a reduction of 1.73 cents per pound of buttermilk powder for these two major inputs. This reduction in cost per pound was caused by the larger volume of production in Plant II.

The work schedule of Plant II is shown in Figure 4. In Plant II, as in Plant I, the dryer operator spent part of the day working at other plant activities. In Plant II the dryer operator tested cream after drying the day's supply of buttermilk. The drying operation was completed before cream testing began. By integrating the dryer operator with the creamery labor force, a sizable reduction in labor cost was obtained. The equipment cost per pound was slightly higher than it would have been if the dryer operator had spent his entire time operating a smaller dryer. As in Plant I, however, the saving in labor cost per pound more than offsets the increased equipment cost per pound. The total processing cost per pound with a full time dryer operator would have been 6.114 cents, the cost per pound with the present work organization was 5.345 cents. A cost reduction of .769 cents per pound was effected by more efficient labor utilization.

Plant III

Plant III, with an annual butter production of 1,250,000 pounds, had a cost of 4.496 cents per pound of buttermilk powder manufactured. The cost per pound for each input is shown in Table 6. Plant III produced buttermilk powder for .849 cents per pound less than Plant II. This reduction in cost was largely due to the decreased equipment cost per unit.

Annual butter production 850,000 pounds

Time	Activity
6:00 A.M.	Sharpen knives
	Heat up dryer, set up splash guards conveyor, and agitate buttermilk
7:00 A.M.	
8:00 A.M.	Dry buttermilk
	Sack and store powder
9:00 A.M.	Keep stoker filled
	Eat lunch at machine
10:00 A.M.	Clean up dryer and floor and shut down equipment
11:00 A.M.	Test cream
12:00 M.	
1:00 P.M.	Wash test bottles
2:00 P.M.	
3:00 P.M.	

Fig. 4. Work Schedule - Plant II.

In Plant III the labor cost per pound was slightly higher than in Plant II. This slight rise was due to a larger percentage of the dryer-operator's time being spent at the dryer. The work schedule for Plant III is shown in Figure 5. The dryer operator spends approximately 93 percent of his time drying milk and the remaining time operating the boiler. In a creamery of this size it becomes more difficult to utilize a portion of the dryer-operator's labor in another part of the plant. The larger volume of butter produced caused more specialization of labor within the plant and it is possible to design the work organization in such a way that all the labor force is used for a full day. At this volume it is possible to operate a dryer economically for a full day. The machinery necessary to do this is no larger than the machinery needed in Plant II and the reduction in cost per pound for machinery is quite substantial.

The two major input items in Plant III were labor and equipment. As volume increased from Plant I to Plant III the fuel cost per pound became relatively more important. This occurred because labor and equipment costs per pound were reduced as volume increased and fuel cost remained constant.

Plant IV

Plant IV, with an annual butter production of 1,430,000

Annual butter production 1,250,000 pounds

7:00 A.M.	Sharpen knives
	Heat rolls, set up conveyors, splash guards and agitate milk
8:00 A.M.	
9:00 A.M.	Dry buttermilk, sack and store powder, keep stoker hopper filled, eat lunch at machine
10:00 A.M.	
11:00 A.M.	
12:00 M.	
1:00 P.M.	Clean up dryer and floor and shut down equipment
2:00 P.M.	Haul out ashes, clean up boiler room and prepare boiler for next day

Fig. 5. Work Schedule - Plant III.

pounds, produced buttermilk powder for 4.03 cents per pound. This represents a reduction of .52 cents per pound from Plant III. The cost per pound for each input is shown in Table 6. The major inputs at this volume are labor, equipment and fuel. When this volume of production is reached the fuel cost per pound becomes as important an input cost as equipment cost per pound. Beyond this volume range it may become more important.

The equipment costs per pound continues to decrease as volume rises; however, it decreases at a slower rate. This is due to the fact that the dryer is operating at almost full capacity and as increments of volume are added the dryer size becomes larger and additional equipment investment is required.

The labor costs per pound also decreased. This is due to the fact that the same amount of labor was used as was used in Plant III. This labor, however, was used with a larger dryer size, and the total cost is spread over a larger volume. The work schedule for Plant IV is shown in Figure 6. The dryer operator spent approximately 93 percent of his time operating the dryer and the remaining time operating the boiler. A larger volume of buttermilk powder was produced in Plant IV for the same total labor cost as in Plant III, and a lower cost per pound for the labor input resulted.

Annual butter production 1,430,000 pounds

Time	Activity
7:00 A.M.	Sharpen knives
8:00 A.M.	Heat rolls, set up conveyors and splash guards and agitate milk
9:00 A.M.	Dry buttermilk, sack and store powder, keep stoker filled, eat lunch at the machine
10:00 A.M.	
11:00 A.M.	
12:00 M.	
1:00 P.M.	Clean up dryer and dryer room and shut down equipment
2:00 P.M.	Haul out ashes, clean boiler room and prepare boiler for next day

Fig. 6. Work Schedule - Plant IV.

In the four hypothetical plants, the same rates per unit and method of measuring inputs was used as was used in the sample plants. The work organization in the hypothetical plants was a designed work organization and not an observed work organization as it was in the sample plants. The costs per pound computed in the hypothetical plants were costs that can be achieved under the stated conditions. Variation in those conditions will necessitate adjustments to account for each variation.

COMPARISON OF COSTS COMPUTED USING THE OBSERVED WORK ORGANIZATION AND COSTS COMPUTED USING THE DESIGNED WORK ORGANIZATION

The processing costs per pound computed with a designed work organization show a marked similarity to the processing costs per pound computed with an observed work organization. The costs per pound for the observed work organization and the designed work organization are presented graphically in Figure 7. In both instances decreasing costs per pound were encountered throughout the volume range of this study. Also, in both cases the greatest reduction in cost per unit occurred in the range of 550,000 to 850,000 pounds of butter produced annually. The reduction in processing cost per pound was more than 1.96 cents for both types of plants in this volume range. The processing cost per pound continued to decrease beyond the 850,000 pound volume; however, the rate of decrease was not nearly so rapid beyond the 850,000 pound volume. Throughout the range of this study the processing costs per pound for the plants with a designed work organization were slightly lower than the processing costs per pound for the plants with the observed work organization. This slightly lower cost per pound is not due to the lower cost per pound for any particular input factor but it is the re-

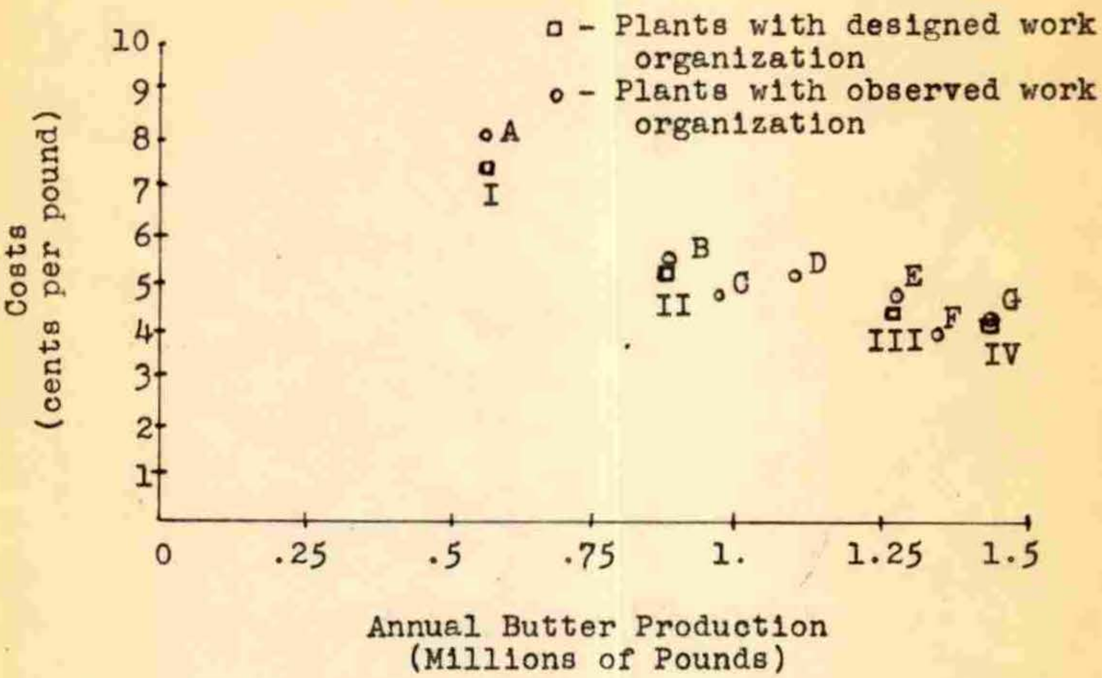

Fig. 7. Relationship between cost of drying buttermilk by roller process and volume of butter production for plants with observed work organization and plants with designed work organization.

sult of combining the inputs in such a way as to obtain the lowest total processing cost per pound.

Figure 7 appears to show that sample Plants C and F had a lower processing cost per pound than plants with a designed work organization would have at that volume. This is not the case. If the volume of Plant II were increased to correspond to the volume of Plant C the processing cost for Plant II would be slightly lower than the processing cost per pound for sample Plant C. This would occur if present equipment in Plant II were retained and the operator's labor were employed full time at the dryer; it would also occur if the size of the dryer were increased and the same work organization retained as is designed for Plant II.

The same result would be obtained if the volume of Plant III were increased to correspond to the volume of sample Plant F. In this case the increased volume could be obtained with the present equipment and labor organization. The extra production would amount to 40 pounds of powder per day in the peak month. This additional volume could be processed by operating the dryer fifteen minutes longer per day, making extra labor or equipment unnecessary. The present labor would be used for 7 hours and 15 minutes instead of 7 hours as it is in the case of Plant III.

If hypothetical plants were constructed for volumes corresponding to the volumes of Plants C and F, the costs per pound in these hypothetical plants would be slightly lower than the processing costs per pound computed for the sample plants. This reduction in cost per pound with increased volume and no change in equipment size indicates that the equipment in Plants II and III is not fully utilized at the present volume of production. However, it is not possible to lower the total processing cost per pound in Plants II and III by installing smaller dryers. A smaller size dryer in Plants II and III would not process buttermilk as economically as the larger equipment now provided for Plants II and III.

EFFECT OF ALTERNATIVE MARKETS UPON NET RETURNS OF BUTTERMILK POWDER

If there is no alternative market for fluid buttermilk the results of this study indicate that, at the present price of buttermilk powder (10-11 cents per pound), a creamery, with an annual butter production of 550,000 pounds, will realize a profit of 3.07 cents per pound of buttermilk powder.

However, if a creamery is considering the installation of a drying system it must also consider its alternative outlets for fluid buttermilk. If there is a centralizer dryer located in the vicinity a creamery could perhaps realize a greater return if the fluid buttermilk were sold to the centralizer dryer. It is also possible that a creamery could dispose of its fluid buttermilk by selling it to the patrons. These alternative markets for fluid buttermilk must be considered by any particular creamery if they are present. Whatever price a creamery can obtain for fluid buttermilk from a centralizer dryer, or from patrons, must be added to the cost of processing to determine the most profitable method of disposal. In effect these alternative prices become the cost of the new material. This is illustrated in Figure 8 where the points on line "a" represent the processing cost plus the price obtained for fluid butter-

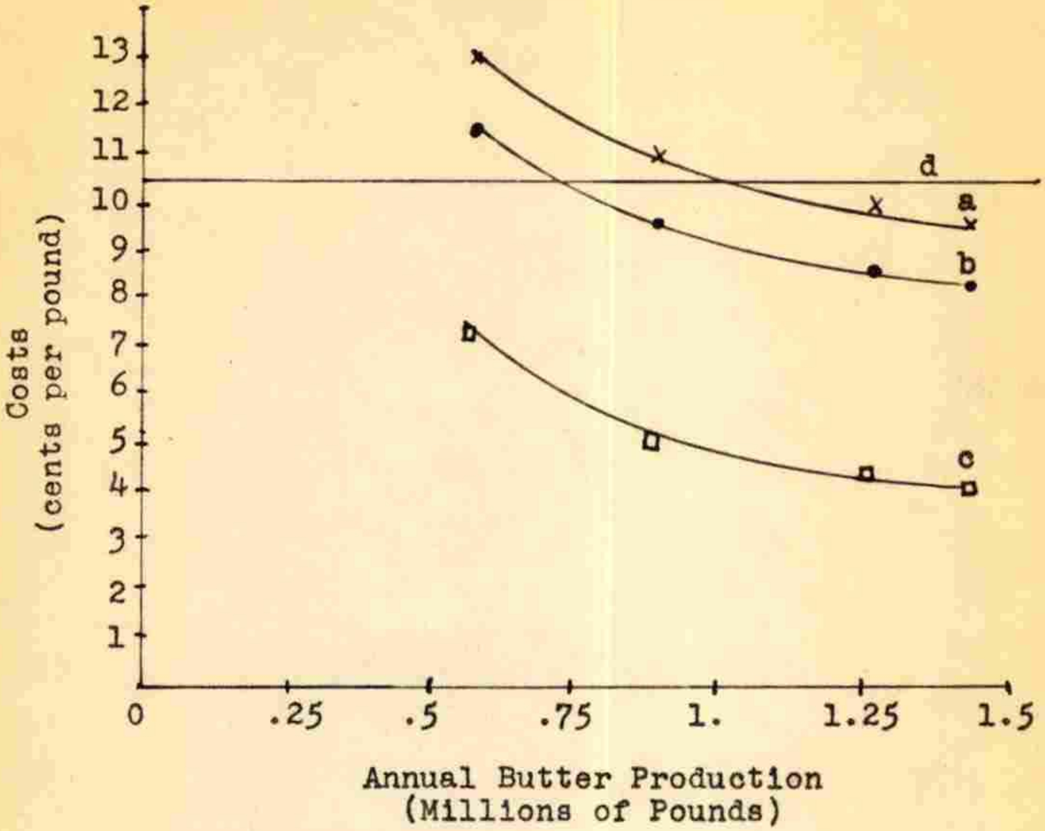

Fig. 8. Returns per pound of buttermilk powder under various assumptions of market outlets.[a]

[a]The points on this graph indicate costs and returns for volumes of 550,000, 850,000, 1,250,000, and 1,430,000 pounds of butter per year. Connecting lines are for purposes of illustration only.

milk from a centralizer dryer, the points on line "b" represent the processing cost plus the price obtained from farmers for fluid buttermilk, the points on line "c" represent the processing cost per pound for buttermilk computed for the hypothetical plants, and "d" represents the present selling price for buttermilk powder. The connecting lines between the points do not represent the costs for the intervening volumes; the cost curves may not be smooth curves. The connecting lines are drawn in for clarity in presentation. This graph shows at what volume it becomes profitable to dry buttermilk with processing costs as calculated and with several alternative outlets for fluid buttermilk.

At the present time centralizer dryers in Iowa are paying 45 cents per hundred pounds for fluid buttermilk. This price is based on 8 percent solids and is F.O.B. plant. This price is equivalent to 5.625 cents per pound for the solids in buttermilk. If a creamery is located close enough to a centralizer dryer to take advantage of this market the price of the solids, 5.625 cents per pound, must be added to the cost of processing. If a creamery had this alternative and met all the conditions stated for the hypothetical plants it would not be profitable to dry buttermilk unless the creamery's volume was greater than one million pounds of butter produced annually. However, if the most profitable alternative outlet for fluid buttermilk was patron sales at three cents per gallon, creameries producing 700,000 pounds of butter annually would find it profitable to dry buttermilk.

On the other hand if a creamery is paying, or expects to pay, an additional sewage charge because of buttermilk disposal, the charge for sewage must be deducted from the processing cost to determine the returns from the drying operation.

SUMMARY AND CONCLUSIONS

The first objective of this study was to determine the relationship that exists between cost of processing buttermilk powder and volume of butter production, in creameries producing one half to one and one half million pounds of butter annually. This relationship is presented graphically in Figure 2. Within the range covered by the sample plants, the cost of production of buttermilk powder decreases as volume increases. This decrease is largely due to the lower cost (per pound of powder) of labor and equipment in creameries of larger volume. Under the assumptions imposed in this study (essentially present building, equipment and labor values), the calculated costs per pound of buttermilk powder ranged from 7.43 cents for the smaller plant down to 4.03 cents for the larger. In many instances a creamery may process buttermilk at a lower cost per pound if used equipment is available, if the present building space is adequate, or if other local conditions exist that may be exploited. The lower cost resulting from exploitation of local conditions will not, however, change the physical relationship that exists between cost of production of buttermilk powder and volume of butter production.

If the conditions existing in a particular creamery are not the same as the conditions stated for the hypothetical plants an adjustment must be made to account for the peculiar conditions existing in that creamery. It is possible to do this by substituting different values into the formula used to compute the physical inputs of a hypothetical plant.

The second objective of the present study was to determine the effect of alternative markets on the net returns realized from buttermilk powder. The effect of alternative markets on net returns is shown in Figure 8. If a creamery is able to sell its fluid buttermilk to a centralizer dryer, at the price stated, it will not be profitable to dry buttermilk unles the creamery produces more than one million pounds of butter annually. If a creamery is unable to sell fluid buttermilk to a centralizer dryer but can dispose of fluid buttermilk to patrons (at the price stated) it will not be profitable to dry buttermilk unless the volume of annual butter production exceeds 700,000 pounds.

The method of disposal of fluid buttermilk in any creamery is the responsibility of the management of that creamery and all the conditions that exist in that creamery must be taken into consideration before any decision is made regarding buttermilk drying. Many creameries in Iowa that produce more than 550,000 pounds of butter annually do not dry buttermilk. It is possible that alternative markets or other local conditions make it unprofitable for those creameries to dry buttermilk by the roller process. It is also possible that the creamery management lacks information concerning the costs of processing buttermilk. If the latter is the case the present study is perhaps helpful in determining the major costs and in indicating the relationship that exists between cost of production of buttermilk powder and volume of production of butter.

SUGGESTIONS FOR FURTHER STUDY

The present study was limited to the lower volume range of butter manufacturing plants presently engaged in drying buttermilk (550,000 to 1,430,000 pounds produced annually) and the processing cost was determined for plants within this range. It would be interesting and valuable to expand this study to determine the processing costs for larger volume plants. Such extension would yield further knowledge of the relationship existing between cost of production of buttermilk powder and volume of butter production. It would also be interesting to examine the feasibility of drying buttermilk for human consumption in both large and small plants. The present study has been limited to powder for animal feed.

In addition to extending the present study to include the larger volume plants an investigation of the processing costs of centralizer drying plants would yield information concerning the feasibility of marketing buttermilk through centralizer drying plants.

The investigation of the processing costs in larger volume creameries would be valuable for plants other than those receiving only cream. Many plants receive milk and separate the cream; these plants have skimmilk as an additional by-product and are seeking information concerning the most profitable method of disposal of skimmilk.

An investigation of the feasibility of roller processing skimmilk should include the processing cost for roller dried skimmilk powder for human consumption. The additional price received for powder for human consumption over powder for animal feed may make the addition of the necessary equipment and labor for such operations profitable, provided the volume is considerable. If the present trend toward fluid milk production in Iowa continues, the problem of marketing skimmilk will become increasingly important. An investigation of the processing costs for roller drying skimmilk will aid milk plants in their decisions concerning the most profitable method of marketing skimmilk. Further investigations along this line are in the planning stage under project 1169 of the Iowa Agricultural Experiment Station.

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APPENDICES

APPENDIX A

Standard Rates Applied to All Plants to Calculate Inputs

Fuel

Prices

Stoker coal 1.5" $4.50 per ton at the mine.
Freight for coal $4.50 per ton from southern Illinois mines.

Fuel oil, No. 2 12 cents per gallon delivered.

Natural gas 36 cents per thousand cubic feet.

These prices were obtained from Iowa coal, oil, and gas suppliers and are considered typical for the type and volume of fuel used in creameries.

Heat content

Coal 11,500 B.T.U. per pound.

Oil 140,000 B.T.U. per gallon.

Gas 1,200 B.T.U. per cubic foot.

These standards were obtained in a conference with Prof. H. M. Black of the Mechanical Engineering Dept., and are considered to be values which are at about the general level of fuels in use in Iowa.

Electricity

Rate per K.W.H. 3.2 cents per K.W.H.

This rate is an average of all rates charged in the sample plants.

Packaging

Price per burlap bag $ .40

Price per waxed liner $ .125

These prices are approximately the prevailing prices for bags and liners when purchased in lots of 1000.

Labor

Monthly wage $ 260.00

Annual wage $3,120.00

This wage is approximately the prevailing wage for dryer operators in Iowa creameries. In peculiar situations the wage may be slightly higher or lower.

Insurance Rate

Building $1.35 per $100

Equipment $1.45 per $100

Workman's Compensation Insurance $ .93 per $100

The rate for building and equipment insurance was obtained from the Iowa Inspection Bureau for 80% coverage and is considered typical for creameries.

The rate for workmen's unemployment compensation was obtained from an Iowa insurance company as being a typical rate for dryer operators.

Taxes

Local property taxes 30 mills per dollar valuation

Payroll taxes 1.8%

The local property tax rate is the same rate used by Frazer, Neilsen and Nord[1] in their investigation of butter manufacturing costs in Iowa creameries.

The payroll tax rate is the existing tax rate, 1.5% for Social Security tax and .3 of 1% for federal tax.

[1]Frazer, Neilsen, and Nord. The Cost of Manufacturing Butter in Iowa Creameries. Iowa State College Agricultural Experiment Station. 1951.

Equipment

Depreciation

The rates used are those rates given for dairy plants in Bulletin F.[1]

Maintenance

The rate of 4% of the investment was used. This was determined after consulting the work of Henry, Bressler, and Frick[2] in related production activities and after discussion with dairy industry personnel thoroughly familiar with the equipment in use.

Building

A standard depreciation and maintenance rate of 4% of the investment was used. This rate is the same rate used by Frazer, Neilsen, and Nord[3] in their investigation of the costs of butter manufacturing in Iowa creameries.

Interest

An interest rate of 4% of the average investment was applied to building and equipment costs. This rate is the same rate used by Frazer, Neilsen, and Nord in the work mentioned previously.

Solids Content

The solids content of buttermilk in hypothetical plants was standardized at 8.7%.

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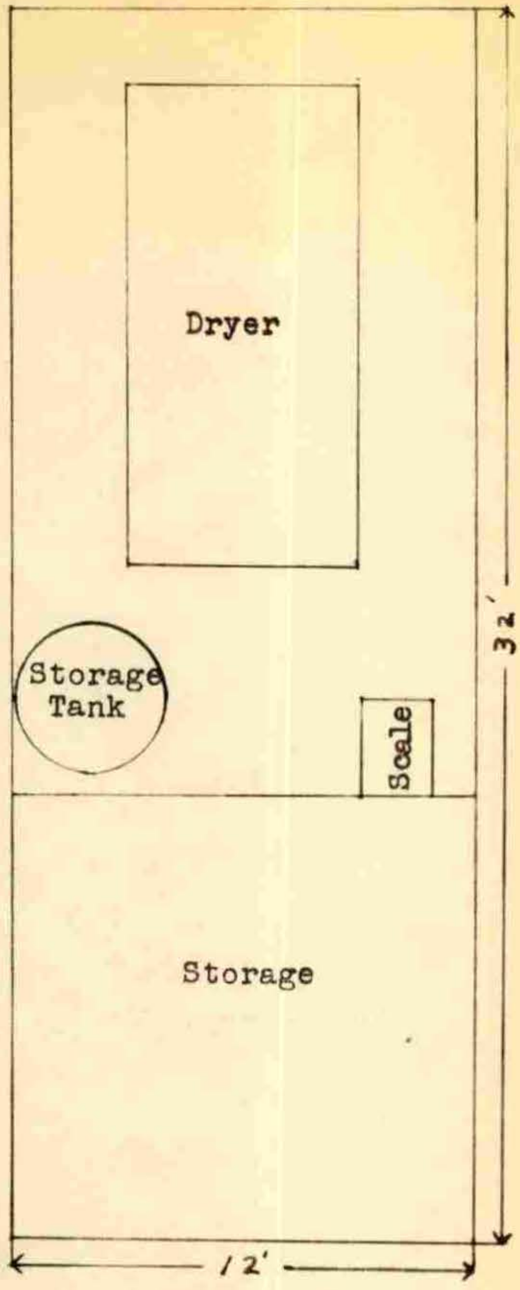
[1] U. S. Treasury Dept. Bureau of Internal Revenue. "Bulletin F," Income Tax Depreciation and Obsolescence Estimated Useful Lives and Depreciation Rates. Revised 1942.

[2] Bressler, Henry, and Frick. "Efficiencies of Milk Marketing in Connecticut" 11. Economies of Scale in Specialized Pasteurizing and Bottling Plants. Bul. 259. Storrs Agricultural Experiment Station.

[3] Frazer, Neilsen, and Nord. op. cit. page 805.

APPENDIX B

Building Space and Equipment Arrangement of Plant I[1]



[1]The equipment arrangement will remain the same for all plants. The building size will change as equipment size and storage space become greater in the larger volume plants.

APPENDIX C

Cost, Size and Estimated Life of Equipment Selected for the Hypothetical Plants

Plant I

Equipment	Size	Cost (dollars)	Estimated Life (years)
Dryer (all necessary accessories included)	24"X60"	10,000.00	20
Storage tank	4'x7' circular	215.00	10
Pump (centrifugal)		95.00	18
Motor	½ H.P.	79.00	14
Platform scale	Portable	75.00	15
Boiler & stocker (50% of total boiler cost charged to drying)	75 H.P.	2,801.00	20

Total equipment investment $13,265.00

Plant II

Equipment	Size	Cost (dollars)	Estimated Life (years)
Dryer (all necessary accessories included)	32"X72"	10,976.00	20
Storage tank	4'X7'	215.00	10
Centrifugal pump		110.00	18
Motor	½ H.P.	79.00	14
Platform scale	Portable	75.00	15
Boiler & stoker (50% of boiler cost charged to drying)	90 H.P.	2,973.00	20

Total equipment investment $14,428.00

Plant III

Equipment	Size	Cost (dollars)	Estimated Life (years)
Dryer (all necessary accessories included)	32"X72"	10,976.00	20
Storage tank	6'X6'	270.00	10
Centrifugal pump		110.00	18
Motor	½ H.P.	79.00	14
Platform scale	Portable	75.00	15
Boiler & stoker (40% of boiler cost charged to drying)	100 H.P.	2,823.00	20

Total equipment investment $14,333.00

Plant IV

Equipment	Size	Cost (dollars)	Estimated Life (years)
Dryer (all necessary accessories included)	90"X32"	11,757.00	20
Tank	6'X8'	355.00	10
Centrifugal pump		110.00	18
Motor	½ H.P.	79.00	14
Platform scale	Portable	75.00	15
Boiler (40% of the boiler cost charged to drying)	125 H.P.	3,025.00	20

Total equipment investment $15,401.00

APPENDIX D

Calculation of the Input Costs of Plant I

Fuel:

8.7 percent = solids in the fluid buttermilk

895 degrees Fahrenheit = latent heat of vaporization

61 degrees Fahrenheit = original temperature of buttermilk

.65 = boiler efficiency

.93 = dryer efficiency

11,500 B.T.U.'s present in one pound of coal

.45 cents = cost of coal per pound

$$\frac{\frac{100}{8.7}(100) - 100\left[(895) + (212 - 61)\right]}{(.93)(.65)(11,500)}(.45)$$

= .71 cents per pound of dry buttermilk

Electricity:

746 watts = theoretical watts per hour per horsepower

8.5 horsepower = total horsepower used in Plant I

.85 = the efficiency of the motors in use

4 hours = time motors in operation per day

340 pounds = powder production per day in the peak season

3.2 cents = price per K.W.H. for electricity

$\frac{(746)(8.5)(4)}{(1000)} = \frac{33.56}{340}(3.2)$ = .32 cents per pound of dry buttermilk

Packaging:

40 cents = cost of burlap bag

12.5 cents = cost of waxed liner

Labor

$3120 = annual wage

75 percent of time spent drying

93 cents per $100 = workman's compensation insurance

1.8 cents per dollar = payroll taxes

79,900 pounds = annual production of dry buttermilk

($3120)(.75) = $2340 annual wage

(23.4)(93) = 22 cost for workman's compensation insurance

(23.4)(1.8) = 42 payroll taxes

Total $2404

$\frac{2404}{799}$ = 3.01 cents per pound of dry buttermilk

Equipment:

Total equipment investment $13,265.00

Depreciation

Dryer	$10,000 at 5%	500.00
Storage tank	215 at 10%	22.00
Pump	95 at 5.6%	5.00
Motor	79 at 8%	6.00
Boiler	2,801 at 5%	14.00
Scale	75 at 7%	5.00
Total depreciation		678.00

Interest

$\frac{13265}{2}$(.04) = $265 Total interest

Maintenance

13265 (.04) = \$530 Total maintenance

Total equipment expense \$1473

$\frac{1473}{79900}$ = 1.89 cents per pound of dry buttermilk

Building:

32' x 12' building size

\$3.60 per sq. ft. = Boeckh's base price

2.23 = adjustment factor computed from the Boeckh Index Calculator to adjust to current building prices

\$8.03 per sq. ft. = adjusted price

(\$8.03)(384) = \$3084 Total building cost

(\$3084)(.04) = \$123 Depreciation and maintenance

$(\frac{3084}{2})(.04)$ = \$ 63 interest

\$186 yearly building cost

$\frac{\$186}{79900}$ = .23 cents = building cost per pound of dry buttermilk

Insurance:

\$1.35 per \$100 = insurance rate on building

\$1.45 per \$100 = insurance rate on contents

.096 per \$100= insurance rate for extended coverage

30.84(.0135) = \$ 42.00

13265(.0145) = 192.00

16349(.00096)= 15.00

\$249.00

$\frac{249.00}{79900}$ = .30 cents insurance expense per pound of dry buttermilk

Taxes:

30 mills per dollar of average investment

$\frac{16349}{2}(30) = \$245.00$

$\frac{245}{79900} = .29$ cents per 100 pounds of dry buttermilk